

BLACK SCORCH OF THE DATE PALM CAUSED BY *THIELAVIOPSIS PARADOXA*¹

By L. J. KLOTZ, *Associate Plant Pathologist*, and H. S. FAWCETT, *Plant Pathologist, Graduate School of Tropical Agriculture and Citrus Experiment Station, University of California*

INTRODUCTION

A fungous disease of economic importance has recently appeared on the date palm, *Phoenix dactylifera*, in the Southwest. The fungus, *Thielaviopsis paradoxa* (De Seynes) Von Höhn.,² has been found attacking all organs of the palm except the roots and stem, and these latter organs have been found susceptible by artificial inoculation. Successful infections by means of inoculations have been obtained on all parts of the date palm, and the organism in all cases has been readily reisolated. While the total losses from this disease up to the present are apparently of minor importance, the severity of its attack in some instances indicates that it may become so troublesome as to require special measures of control.

DISTRIBUTION

In the so-called "bud-scorch" form of the malady is widely distributed, being present in every garden inspected in the Coachella Valley, Calif., and Arizona. It has also been found on ornamental date palms at Riverside, Calif. Other workers have found that the fungus parasitizes a number of plants, including areca palms, oil palms, sugarcane, coconut, and pineapple. Edgerton (3)³ describes it as causing great damage to sugarcane. Although it has not been reported as occurring on Citrus, the writers have found that it produces a firm, dark, smoky-colored, pleasantly aromatic decay when introduced into wounds of citrus fruits. In India, Sundararaman, Krishnan Nayar, and Ramakrishnan (11) have shown experimentally that it is capable of attacking plantain, mango, *Saccharum spontaneum*, *Rhapis* sp., and the date palm. Except in the abstract by Klotz and Raby (8) and in papers by Fawcett (4) and Klotz (7), it is believed that the organism has never been reported as attacking the date palm naturally. On preserved specimens of apparently the same disease collected by Fawcett (4) in Egypt, Algeria, and Tunisia, the writers have found conidia typically like those of *Thielaviopsis*. How seriously the fungus attacks the inflorescences and lessens the quantity of fruit depends upon weather conditions preceding and during the time of emergence of the spathes. It is likely that mildly warm, moist weather accompanying or alternating with windy weather favors distribution and infection. The optimum temperature for growth of the fungus lies between 24° and 27½° C. The manner in which the conidia are borne (in extremely long chains, which readily break up into small groups and single conidia) favors distribution by wind. Germination of the spores on glass is possible only in the presence of water in liquid form.

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² Identified by J. A. Stevenson, of the Division of Mycology and Disease Survey, Bureau of Plant Industry, U. S. Department of Agriculture.

³ Reference is made by number (italic) to Literature Cited, p. 165.

SYMPTOMS OF THE DISEASE

ON SPATHE, FRUITSTALK, AND FRUIT STRANDS

As shown in Figure 1, the parasite attacks the young fruitstalks and fruit strands even before the spathe has ruptured. On the spathe, circular to elongated lesions mark the points of entrance of the disease. These lesions range in color from sorghum brown (Ridgway)⁴ on the

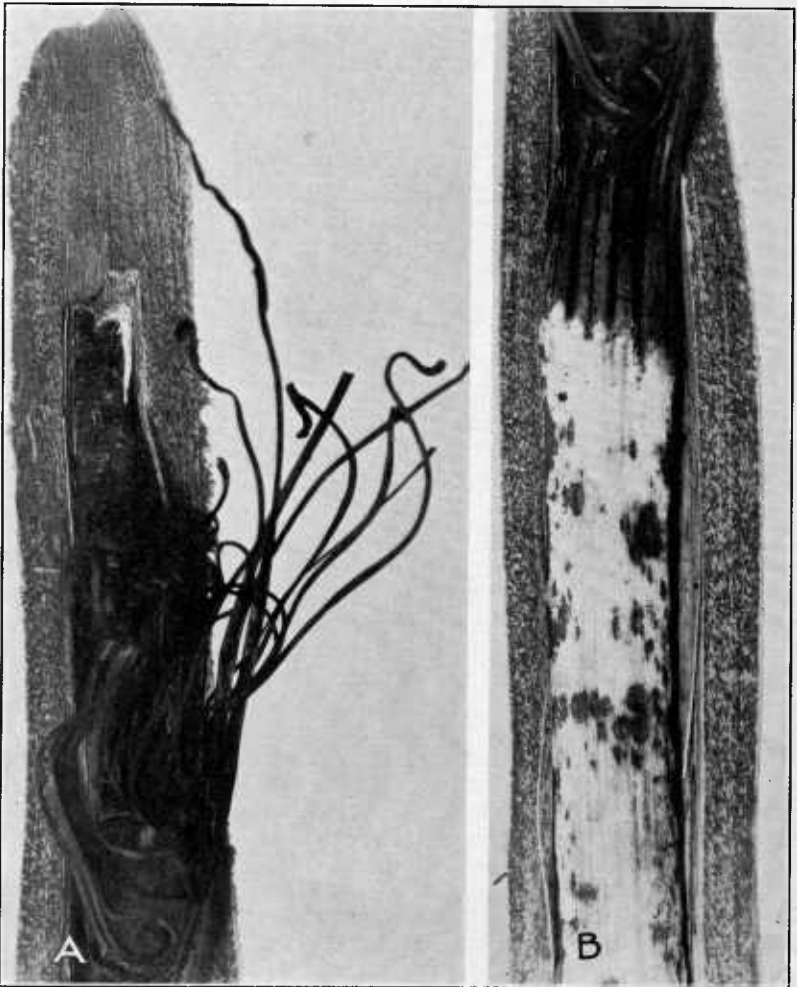


FIGURE 1.—Female spathe cut open to show (A) black scorch on inflorescence, the gnarled and twisted fruit strands being devoid of flowers; (B) lesions on fruitstalk

exterior surface to mahogany red or bay on the interior surface. On removal of a portion of the infected spathe it was found that the fruitstalk bore depressed, brown (warm blackish) to black necrotic areas, which were circular to oblong in outline. The twisted deformed fruit strands of the specimen shown in Figure 1, A, were entirely diseased.

⁴ RIDGWAY, R. COLOR STANDARDS AND COLOR NOMENCLATURE. 43 p., illus. Washington, D. C. 1912.

They were blackish brown to black in color, and were devoid of flowers. Microscopic examination showed them to be covered by the typical dark-brown, unicellular, oval conidia. The strands of fruit bunches that were attacked later in their development showed blackened, depressed lesions (fig. 2) similar to those on the fruitstalk, and some were completely severed by the decay. The affected tissue was in all instances dry and firm and each area bore the black powdery spores. A gray covering on some of the lesions was found to be due to conidia of *Fusarium* sp. A species of *Fusarium* was later found as the primary cause of a decay of certain male inflorescences of the date palm. Inoculations by means of spore suspensions of *Thielaviopsis* into young spathes which were just beginning to crack open showed that wounding was unnecessary for infection, the typical dark lesions being produced on the young tender fruit strands and fruitstalks.

ON TERMINAL BUD

The effect of the disease on the palm bud and heart is even more serious than it is on the fruitstalks. The pathogene gains entrance to the succulent tissue through a wound or puncture, and its progress in this vital region is very rapid. The entire terminal bud and adjacent leaf bases may succumb, eventually presenting a dried, dull, blackened, charcoallike appearance. Two large date seedlings in boxes in the greenhouse were killed by inoculations at the base of the young central leaves. In four of the five cases observed in the field the entire bud was not killed but grew out laterally, producing the so-called "fool disease" effect (called by the Arabs "medjnoon"). It is believed that in California *Thielaviopsis paradoxa* is the principal organism causing this peculiar trouble. Eventually, the entire bud regenerates from the uninjured portions of meristematic tissue and returns to its normal vertical position. High temperatures and rapid growth of the palm may be the factors that operate to prevent the disease from terminating fatally in all instances. On laboratory media the fungus makes very little growth at 32° C. or above.

ON THE PETIOLE, MIDRIB, AND PINNAE

The blackening of the midrib of fronds that usually accompanies the bud-scorch form of the disease may frequently be due to the same organism. The black, irregular, rough, necrotic condition of the leafstalk (fig. 3) is the most striking symptom of the disease. It gives the impression that the tissues have been burned, and suggests the name selected for the disease—black scorch. The cross cuts and V cuts so commonly found near the base of a midrib present an ideal entrance for this and other fungi.

Ashby (1) and Orian (9) have reported the fungus as attacking the pinnae of the freshly opened leaves of coconut palm. "Pale yellow spots with a brown margin develop on the furled pinnae. Later the lesions elongate, converge, and turn black, owing to the presence in the tissues of spores of the fungus. Infection spreads rapidly through the pinnae, and in severe cases the heart leaves dry up." This, so far as it goes, is an accurate description of the course of the disease produced by the writers on a large seedling in the greenhouse. On this seedling and on material collected in the field, the midribs and pinnae had circular to elongated irregular spots, which in some in-

stances were as wide as the pinnae and as much as 5 centimeters in length. Artificial wounding was unnecessary to secure infection on the petiole, midrib, and pinnae. The fungus readily invaded the margin of the petiole where the fibers originate. Twenty days after



FIGURE 2.—Black-scorch lesions on fruit strands. $\times 3\frac{1}{4}$

spores were placed on a leaf of a seedling palm, both edges of one petiole had lesions 3 to 10 millimeters in depth and 150 millimeters in length. (Fig. 4, A.) In the chlorophyll-less region of the petiole

base, the lesion was yellow ocher in color,⁵ and in the green region, Dresden brown. The outer margin of the lesion was dark brown to black, while the inner margin was a light chestnut brown. The central area

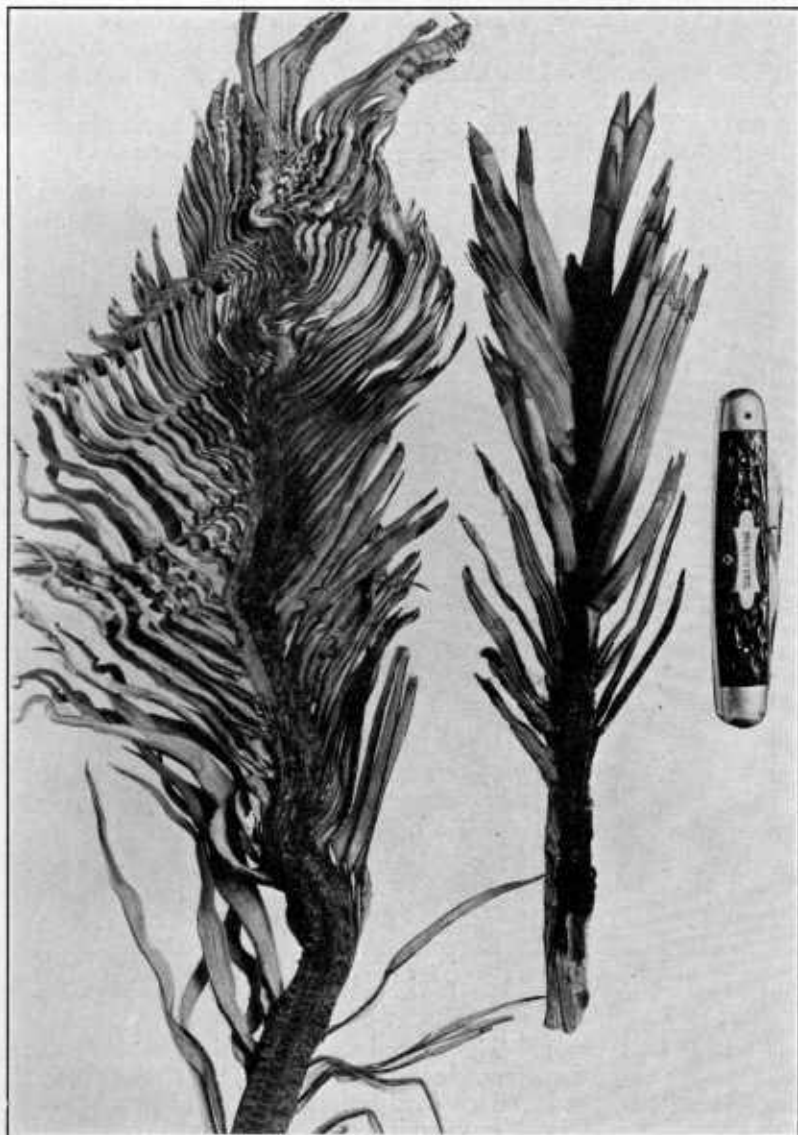


FIGURE 3.—Deformed young date fronds showing charcoal like effect that follows infection by black scorch; the fungus may accompany the deformity but does not necessarily initiate it

(17 by 10 millimeters) of a typical isolated spot (20 by 16 millimeters) on the dorsal surface of the same petiole (fig. 4, A) was chestnut brown, bounded by a narrow margin of deep brown to black. Black

⁵ RIDGWAY, R. Op. cit.

spore masses were scattered throughout this area. Surrounding the inner area was a band 2 to 3 millimeters in width and yellow ochre in color. The margin of the band was a light chestnut brown. Figure 4, B, shows typical spots on the pinnae. These ranged in size from microscopic to 20 by 8 millimeters. Their color characters were similar to those given for the spot on the petiole. However, as a lesion on a pinna dries, the chestnut-brown center gradually becomes lighter until it is a warm buff.

Several midrib bases of the second whorl of fronds on a large seedling offshoot were inoculated by placing the fungus in a 3-millimeter hole

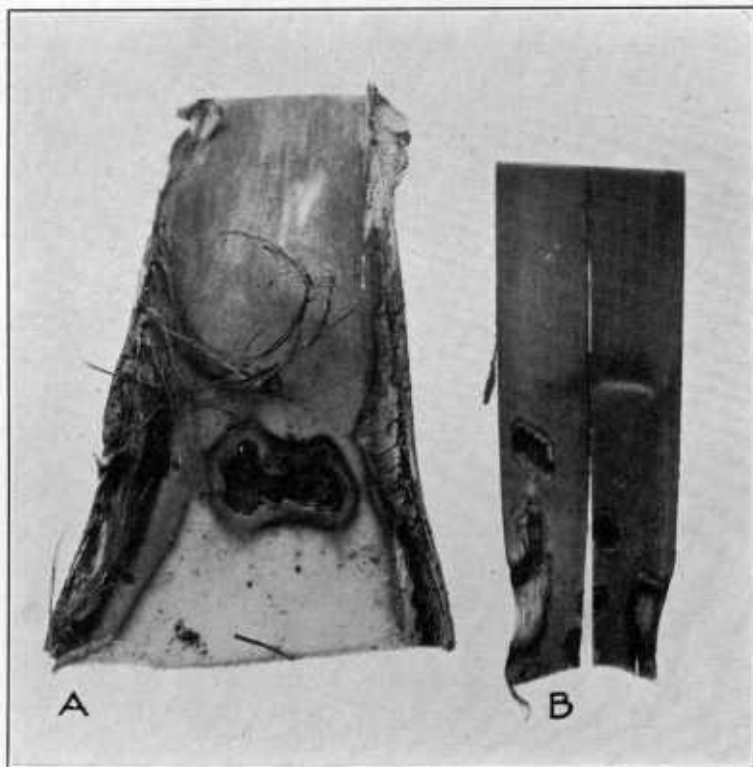


FIGURE 4.—Lesions on petiole base (A) and pinna (B) produced by fungus in absence of wound. The petiole margins where the fibers originate should be considered as wounded tissue

made with a cork borer. The wound was covered with adhesive tape until the organism had become established. In four weeks the fungus on one frond had produced an oval lesion 9 centimeters wide and 15 centimeters long, almost enveloping the midrib and causing it to break. Extending for a total length of 45 centimeters up and down the surface of the midrib beyond the lesion was a linear series of circular water-soaked areas each about 12 millimeters in diameter. The fungus was reisolated from the water-soaked area most remote from the point of inoculation, which shows that the organism invaded new tissue at the rate of at least $1\frac{1}{2}$ centimeters per day for 30 days. The surface of the canker was gray to brown to drab in color, and the

pinnae beyond turned gray as they dried. Internally the lesion was light drab to wine in color toward the advancing edges, with smaller orange to reddish-brown streaks extending far up and down the midrib. (Fig. 5.) These streaks were directly under the water-soaked areas that appeared on the surface. The pathogene was readily reisolated from any portion of the affected tissue. Eventually the invaded tissue turned black owing to the production of fuscous spores by the causal fungus. Likewise, inoculations of any pruning cuts and the cut surfaces of midribs and spines were invariably successful, the infected tissue dying back several inches and eventually becoming blackened and covered by fungous spores.

ON STEM AND ROOT INDUCED BY ARTIFICIAL INOCULATION

To test the susceptibility of the trunk or stem of date palm to the fungus, the old leaf bases were cut away, the surface cleaned with alcohol, and a portion of an agar culture inserted in a hole made with a quarter-inch cork borer. The inoculation was covered with adhesive tape. Five weeks later an examination revealed a zone of dead and dried brown tissue extending in all directions from the point of inoculation. The dark spores of the fungus were present in this region. Beyond the dead tissue was a narrow, pinkish zone about 6 millimeters in width, and beyond that a tumeric-yellow band about 25 millimeters wide. The diseased tissue extended 7 to 10 centimeters from the focus of infection. It was brown to drab in color beyond the yellow zone and had no well-defined margin. It is difficult to determine the extent of diseased areas because the excised tissue darkens rapidly in the air.⁶

Roots of the date palm were likewise tested. On the northwest side of a seedling palm, 15 roots about 12 millimeters in diameter were carefully uncovered. Eight of these were inoculated; some by simply placing agar inoculum on the unbroken surface, and others by inserting the fungus in a 12-millimeter longitudinal slit made with a scalpel and covering the place of inoculation with moist cotton and waxed paper. All of the inoculated roots decayed, the affected portions being a soft, moist, brown decay which became a darker brown as the fungus fruited. In five weeks the affected tissue extended from 5 to 15 centimeters in both directions from the point of inoculation along the root. The inoculated roots, wounded and unwounded, showed no decay. The organism was reisolated from the diseased stem and roots.

VARIETAL SUSCEPTIBILITY

The midrib-scorch form of the disease has been found on all varieties of date palms growing in the Southwest, except the Tazizaoot. Although the fungus was first found causing inflorescence decay on the Deglet Noor, this variety in the Coachella Valley is perhaps one of the least susceptible to other forms of the disease. The Thoory variety appears to be very susceptible to the midrib-scorch form of the malady. The fibers of the midribs of the outer whorls of leaves seem to bind, and as growth proceeds from the center, to injure the young emerging fronds, thus affording an excellent opportunity for infection

⁶ R. B. Streets, of the University of Arizona, at the 1930 Date Growers' Institute reported orally on a disease of the stems of neglected date palms in Arizona having symptoms similar to those on trunk tissue described here. The name of the organism was not mentioned at the time, but later it was identified as a species of *Thielavia* (6).

by the black-scorch fungus, even in the absence of moisture. Winds probably accentuate this type of mechanical injury. The cross cuts

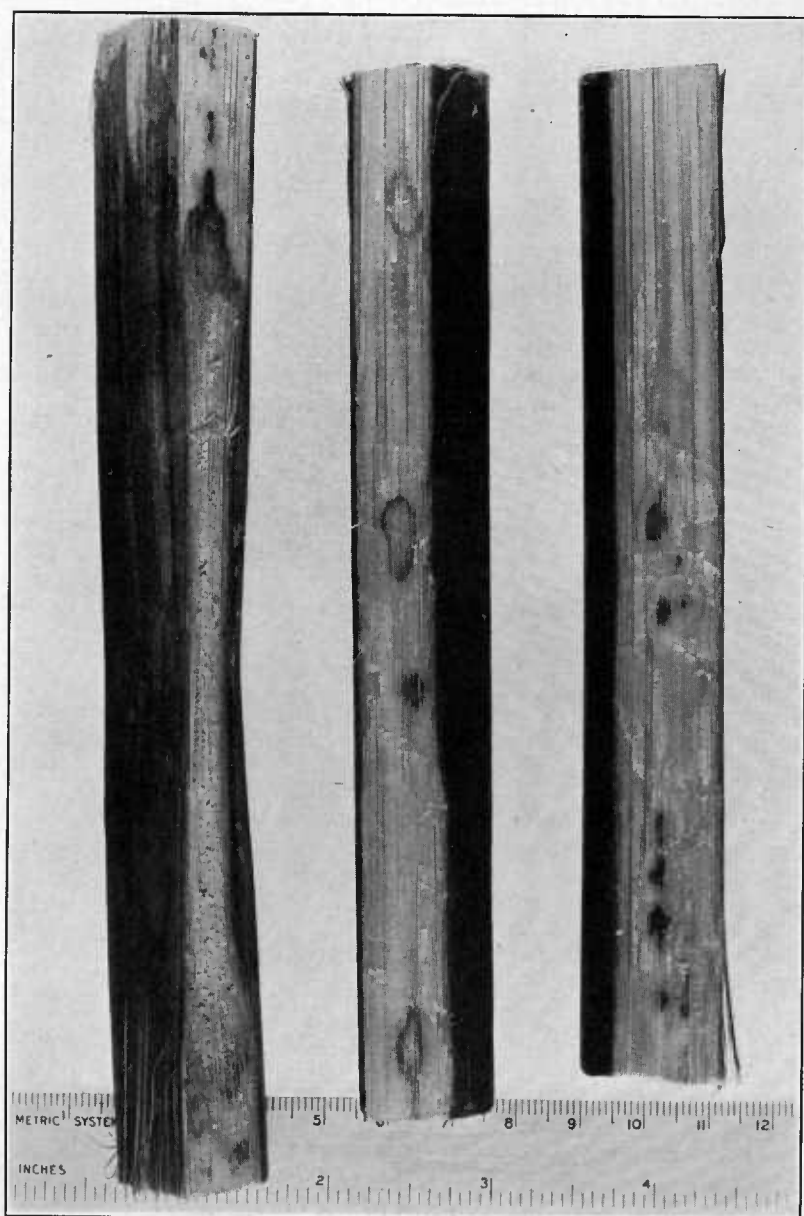


FIGURE 5.—Diseased internal tissues of petiole produced by artificial inoculation with the black-scorch organism

and V cuts mentioned earlier probably have the same origin. The abundance of the disease on the Thoory variety may be due to the greater incidence of this type of injury on that variety.

The Hayany, Amhat, Saidy, and Halawi varieties are likewise very susceptible, perhaps more so than the Deglet Noor. The disease was observed also on the Zaheedy, Menakher, Baklany, Guntar, Haloo, Fteemy, Besser Haloo, Nakleh-Zian, Sukar-Nabat, Horra, and and Koroeh, but the number of individuals was too small to permit reliable comparison.

THE PATHOGENE

Patterson, Charles, and Veihmeyer (10) discuss the origin and synonymy of the fungus, stating that De Seynes found it on pineapple and described it under the name *Sporoschisma paradoxum*. Saccardo in 1892 gave it the genus name *Chalara*, the binomial becoming *Chalara paradoxa* (De Seynes) Sacc. The next year, Went in Java described a serious fungus disease of pineapple and designated the pathogene by the new generic name *Thielaviopsis* because it produced hyaline conidia endogenously in a manner similar to that of the genus *Thielavia* Zopf, and by the specific name *ethacetica* because of the production of a pleasant, strong odor resembling ethyl acetate. Von Höhnelt (5) observed that the fungus of De Seynes and that of Went were identical and established the priority of the specific name of the former, calling the fungus *Thielaviopsis paradoxa*; hence, *Thielaviopsis paradoxa* (De Seynes) Von Höhnelt.⁷ Butler (2) states that he found also a pycnidial stage of the fungus which might place it in the genus *Sphaeronema*. The pycnidia were globose, hairy, and ostiolate, the ostiole being at the tip of a long bristlelike neck. The pycnidiospores were small (10 to 12 μ by 3 μ), hyaline, unicellular. Patterson et al. (10) mention the appearance of pycnidia in their cultures of the fungus, but do not describe this stage. Thus far the writers have observed no pycnidial stage on specimens or on the various laboratory media.

The literature in general describes the fungus as having creeping, almost hyaline hyphae which bear two spore forms: Microconidia, which are small (10 to 15 μ by 3.5 to 5 μ), cylindrical, hyaline, and formed uniseriately within a hyphalike conidial case; and macroconidia (16 to 19 μ by 10 to 12 μ), which are extruded in chains from the tips of short lateral hyphae, and which are brown, thick-walled, and ovate. Grown on glucose-potato agar at 27° C., a culture 2 weeks old had conidia of the following dimensions: The so-called macroconidia with thick walls, length 11 to 17 μ , width 7 to 15 μ ; brown conidia that were extruded from conidiophores of the same morphology as those that bear the hyaline so-called microconidia, length 6 to 23 μ , width 4 to 8.5 μ ; and hyaline microconidia, length 5 to 15 μ , width 3 to 7 μ . The contents of both kinds of conidia vary greatly and may be very guttulate and granular to perfectly homogeneous. As shown in Plate 1, *a*, the typical conidiophores bearing the microconidia are much elongated and swollen at the base, while those bearing the macroconidia (pl. 1, *b*) are approximately half as long as the first and of uniform diameter. However, these distinctions as to spores and conidiophores are very artificial, as one finds all gradations in size, color, and shape between the extremes described, and all the conidia are probably produced endogenously, although some are pictured which appear to originate

⁷Dade (2a) has found a fungus of the genus *Ceratostomella* which he considers to be the perfect stage of *Thielaviopsis paradoxa*; the name of the organism would thus become *Ceratostomella paradoxa*.

acrogenously. In germinating on glucose-potato agar, the protoplast of the mature macroconidium bursts through a longitudinal slit and forms a globule of naked protoplasm which proceeds to grow into mycelium. (Pl. 1, *c*.) In water, the conidia germinate directly by sending out a germ tube. Apparently the brown conidia need a rest period before they will germinate. The hyaline conidium germinates readily without a rest period, sending out one (pl. 1, *d*), occasionally two, germ tubes from any place on its periphery. The hyphae are subhyaline with cross walls and show a strong tendency to anastomose and to form branches at right angles to the parent hypha. (Pl. 1, *e*.)

PATHOLOGICAL HISTOLOGY

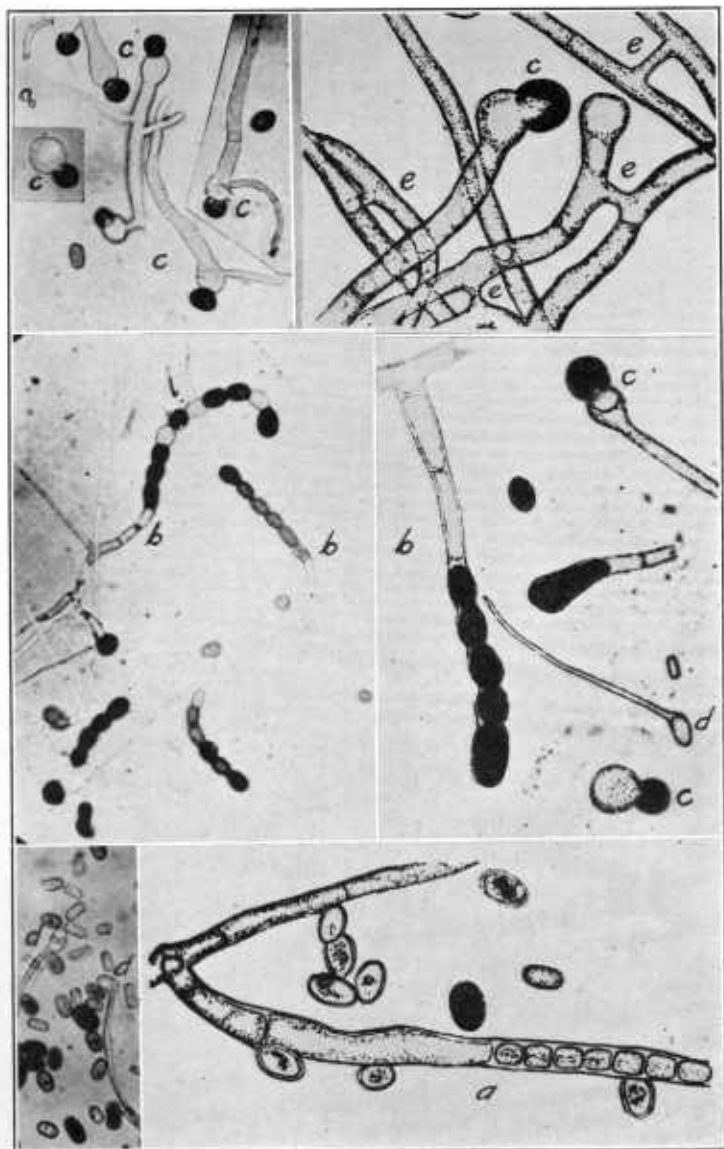
The cells of affected tissues turn brown as both walls and lumen become filled with gum. The formation of gum in palm fronds is not peculiar to this disease alone, for any wound induces a tendency to the formation of pentosanlike substances. In some sections the hyphae appear completely to fill some of the tracheae and parenchymatous cells. (Pl. 2.) These hyphae and the gum that forms in the pathological tissues may become so abundant as to interfere seriously with the transpiration stream and produce a permanent wilting of the pinnae several feet beyond the region invaded by the fungus. In addition to the intracellular growth, the fungus is found abundantly in the intercellular spaces but does not appear to grow in the region of the middle lamellae. Abundant fruiting occurs on the surface of a lesion and, as the decay progresses, within the disintegrated tissues.

CONTROL

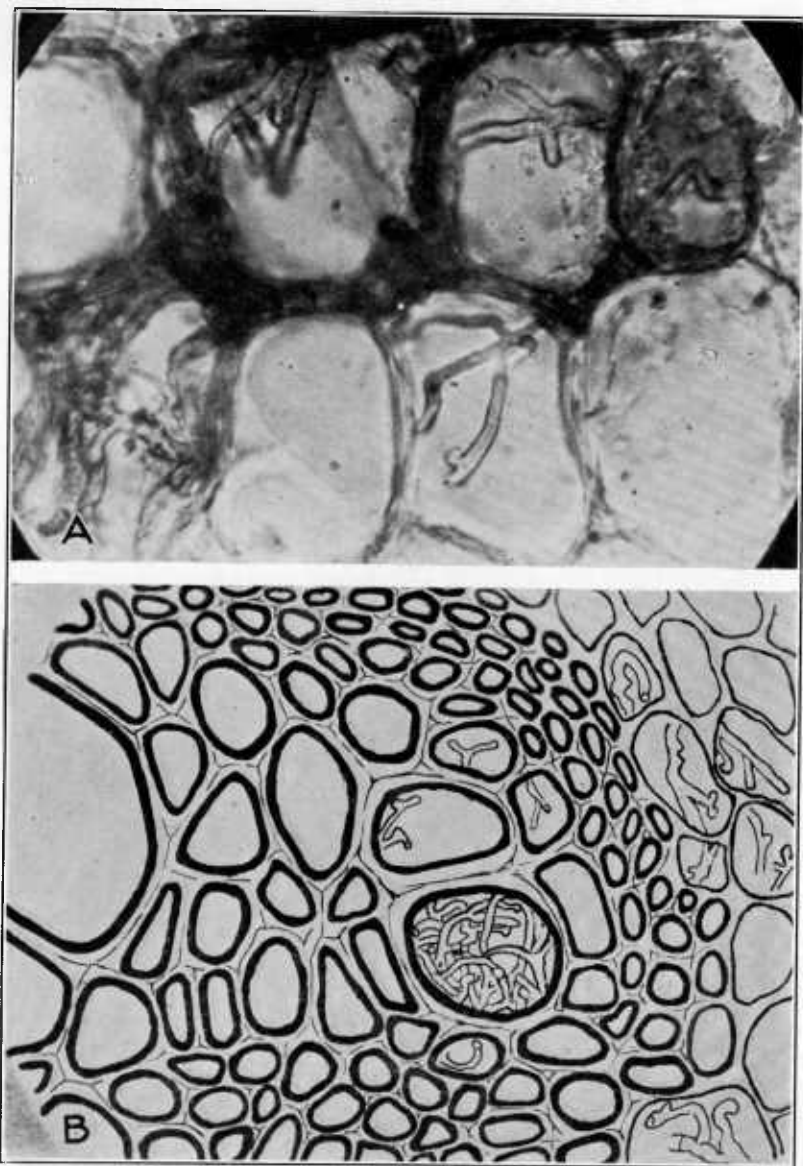
In the West Indies, dipping in 4-5-40 Burgundy or Bordeaux mixture gave adequate control of the disease on sugarcane sets. In Jamaica, where the malady occurs on coconuts, the diseased tissues are excised and the wounds dressed with a mixture of equal parts of copper sulphate, salt, and lime. Patterson et al. (10) found formaldehyde gas (1,200 cubic centimeters commercial formalin per 1,000 cubic feet) effective in controlling the fungus on pineapples, even when the organism was inserted to a depth of half an inch. Simmonds⁸ in Australia has utilized both benzoic acid and boric acid effectively in controlling decay of pineapples. In this work the copper fungicides were less effective than the two organic acids.

In the case of date palms it seems advisable to prune out the affected fronds, leaf bases, and inflorescences, and to protect the pruning cuts and surrounding tissues with some disinfectant. Some preliminary laboratory experiments made by the writers indicate that copper sprays and dusts may be effective. Bordeaux dust, a 5-5-50 Bordeaux mixture, and ammoniacal copper carbonate inhibited germination of the conidia in a weak glucose-potato broth or in 10 per cent sucrose solution, the last-named fungicide being slightly less effective than the Bordeaux. Calcium monosulphide dust, dry lime sulphur, liquid lime sulphur, 1 per cent boric acid, 1 per cent benzoic acid, and 1 per cent formalin were likewise effective in inhibiting germination. All the chemicals in liquid form except

⁸ Verbal communication.



Left, photomicrographs, \times approximately 200; right, tracings of photomicrographs showing: *a*, Microconidiophore with endogenous hyaline conidia; *b*, macroconidiophores with fuscous macroconidia; *c*, macroconidium germinating; *d*, microconidium germinating; *e*, anastomosing hyphae, \times approximately 400



A, Photomicrograph of hypha in parenchyma of petiole, \times approximately 320; B, tracing from a photomicrograph of transverse section of petiole, showing hyphae in tracheal tubes and in parenchyma, \times approximately 160

the formalin were atomized onto glass slides and allowed to dry before the spore suspension was applied with an atomizer. Flowers of sulphur dust under the conditions of the experiment was entirely ineffective in preventing germination.

SUMMARY

A fungous disease of economic importance has been found on date palms in California, Arizona, and northern Africa. A preliminary survey indicates that all varieties of the date palm are probably susceptible. The disease has been found occurring naturally on all parts of the plant except the roots and stem, and these latter organs have by artificial inoculation been found to be readily susceptible.

Typical lesions are dark brown to black, hard, carbonaceous, and in mass give the petioles, midrib, fruit strands, and fruit stalks a scorched appearance, which suggests "black scorch" as the common name. Many of the fruit strands may be completely severed by the attack and the crop materially lessened. Wounding was shown to be unnecessary for infection of the root, fruit strands, petiole, and pinnae. The decay is most serious when it attacks the terminal bud, either killing the palm, or, when not fatal, producing the so-called "fool disease" effect, in which the injured terminal bud grows out laterally, setting the normal growth of the palm back several years.

Both the hyaline and the brown spores of the fungus *Thielaviopsis paradoxa* (De Seynes) Von Höhnelt are found on the surface of the lesions. The conidia originate endogenously in uniseriate chains from subhyaline conidiophores. The optimum temperature for the fungus in culture lies between 24° and 27½° C.; it makes very little growth at 32°. The brown spores apparently need a rest period before germination. The hyaline conidium germinates readily without a rest period, sending out one, and occasionally two, germ tubes from any place on its periphery. In germinating on glucose-potato agar the protoplast of the mature macroconidium bursts through a longitudinal slit, liberating a globule of naked protoplasm which proceeds to grow into mycelium. The hyphae are subhyaline with cross walls and show a strong tendency to anastomose and to form branches at right angles to the parent hyphae.

A histological study of the petiole of a diseased frond showed the fungus growing intracellularly in tracheae and parenchyma and intercellularly in the intercellular spaces but not in the middle lamellae.

To control the malady, the affected fronds, leaf bases, and inflorescences should be pruned out and the pruning cuts and surrounding tissues protected with some disinfectant. Preliminary experiments indicate that copper sprays, dusts, and various other chemicals may be effective.

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